

# NRC INSPECTION MANUAL

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## INSPECTION PROCEDURE 61710

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### CONTROL ROD WORTH MEASUREMENTS FOR PRESSURIZED WATER REACTORS

PROGRAM APPLICABILITY: 2515 (SUPPLEMENTAL)

#### 61710-01 INSPECTION OBJECTIVES

The objectives of this procedure are:

01.01 To verify that control rod worth measurement procedures follow license commitments (e.g., ANSI Standards and core reload analysis reports),

01.02 To verify that control rod bank worth measurements are conducted in accordance with licensee procedures,

01.03 To verify that control rod bank worth measurement calculations are correct, and

01.04 To verify that control rod bank reactivity worth values are within their acceptance criteria.

#### 61710-02 INSPECTION REQUIREMENTS

02.01 Review the licensee's procedure for measuring differential and integral rod worth. Determine the adequacy of this procedure by comparing it to the license commitment documents of 01.01, above.

02.02 Review the retained records for recent control rod bank worth measurements. If possible, observe actual measurements as they are conducted. Verify that:

- a. Prerequisites and initial conditions were met.
- b. Precautions and limitations were observed.
- c. Plant conditions were maintained as specified in the procedure. Changes or relaxations of plant conditions were approved by the appropriate licensee personnel (e.g., chief test engineer) and any other procedural deviations were similarly approved.

- d. Reactor coolant and pressurizer boron concentration samples were taken at periodic intervals (typically 30-minute sampling frequencies).

- e. Calculations of control rod bank reactivity worths are correct. This includes the application of necessary correction factors.
- f. Values obtained for control rod bank worths are within the acceptance criteria generated from analytical prediction of core reactivity and control rod neutron absorption characteristics.
- g. The licensee has properly resolved any discrepancies between actual measurements and predicted reactivity worths.

## 61710-03 INSPECTION GUIDANCE

### General Guidance

- a. Measurement Purposes. The purposes of measuring control rod bank reactivity worths are to verify they are in accordance with design predictions and assist in the verification of adequate shutdown margin (the determination of shutdown margin is a Technical Specification requirement).
- b. Reactor Conditions. The reactivity worth of each control rod bank (or group) is typically measured with the reactor maintained critical at hot zero power. An attempt is made to maintain reactor coolant temperature and pressure constant throughout each test. The test procedure should call for periodic recording of reactor parameters such as reactor neutron level, reactor coolant system temperature, pressure and boron concentration, and pressurizer boron concentration.
- c. Control Rod Reactivity Worth Measurement Methods. Two control rod reactivity worth measurement methods are typically used.
  - 1. Boron Exchange Method. Boron concentration is changed in a continuous manner. One control rod bank is incrementally moved over its full travel in response to the changing boron concentration. Differential control rod bank reactivity worth values ( $\Delta\rho/\Delta h$ ) are calculated using the reactivity computer. Differential control rod bank reactivity worth curves are then plotted versus bank height ( $\Delta\rho/\Delta h$  vs.  $h$ ). The inspector should verify that the licensee's method of conversion from reactivity measured per unit time to reactivity per unit rod length is correct and reasonable. Corrections must be included for changes in reactor coolant system parameters during the test. An integral control rod bank reactivity worth curve ( $\sum\Delta\rho$  vs.  $h$ ) is produced directly from the differential curve for that bank.
  - 2. Rod Swap Method. Prior to this test, the control rod bank reactivity worth curve for a reference control rod bank must be determined using the boron exchange method of 03.01c1 above. The reference control rod bank is withdrawn from its fully inserted position while inserting the test control rod bank from its fully

withdrawn position. A critical condition is established with the test control rod bank fully inserted. The position of the reference control rod bank is recorded. The integral control rod bank reactivity worth of the test bank is determined from the integral control rod reactivity worth curve for the reference bank. Corrections are made for changes in reactor coolant system parameters during the test.

- d. Control Rod Bank Sequence for Boron Exchange Method. Typically, the reactivity worths of the control rod banks are measured during dilution in the normal order in which the banks are inserted into the core, but without overlap (each bank is fully inserted before moving the next bank). The reactivity worths of the banks are then measured a second time during boration while a normal overlap withdrawal sequence is followed.
- e. Because residents are generalists and do not have extensive experience and technical expertise in the core physics field, this inspection procedure should be performed by regional inspectors during the startup physics testing sequence for each refueling outage.

#### 03.01 Specific Guidance

- a. Inspection Requirement 02.02a. Typical prerequisites and initial conditions for these measurements are as follows:
  - 1. Operational alignment of the neutron monitoring system has been satisfactorily completed.
  - 2. The reactivity computer is installed and operational. The reactivity computer is usually connected to an upper detector of one excore detector string and to a lower detector of an adjacent detector string to obtain a more representative flux profile of the core.
  - 3. Chemistry support is available to sample the reactor coolant system and pressurizer for boron concentration at the required intervals.
  - 4. The reactor is critical at hot zero power. Reactor neutron flux is at the level prescribed in the licensee procedure.
  - 5. Control rod banks are in their specified positions. The control rod mode switch is in the position specified in the licensee procedure (e.g., MANUAL or AUTO).
- b. Inspection Requirement 02.02b. Typical precautions and limitations for these measurements are as follows:
  - 1. A limitation on the maximum startup rate and boron dilution rate allowed during the procedure.

2. Control bands to be observed for reactor coolant system temperature and pressure.
3. A maximum neutron flux level and/or reactor power limit.
4. The maintenance of proper overlap or no overlap conditions during specific steps of the procedure.
5. Positive adherence to unrelaxed core parameter requirements such as hot channel factor or radial or axial flux peaking limits.
6. Awareness and understanding of applicable Technical Specification requirements (e.g., rod group height and rod insertion limits).

61710-04 REFERENCES

Technical Specifications

Core Reload Analysis Report

Applicable Fuel Vendor Reports

ANS-19.6.1, "American National Standard Reload Startup Physics Tests for Pressurized Water Reactors," (To be published Fall 1985).

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